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Abstract

This paper shows that the general foreclosure result claimed by Salinger in his 1988 QJE article is incorrect. Extending Salinger's model, I develop a two–stage game form and derive explicit conditions for integrated firms to supply or foreclose the intermediate good market. The emergence of either the foreclosure or vertical supply equilibrium is endogenous. It depends on the number of integrated firms and unintegrated upstream and downstream firms. Foreclosure arises in duopoly cases and is also supported by a small number of downstream firms and a large number of upstream firms. Vertical supply, on the other hand, is admissible for a broad range of parameter values and is supported by a large number of downstream firms and a low number of upstream firms. (*JEL* L22)

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1 Introduction

The conduct of vertically integrated firms on intermediate good markets is a controversial issue in industrial economics. In an important paper, Michael A. Salinger (1988) analyses markets with differing numbers of integrated firms and unintegrated upstream and downstream firms. His approach overcomes the limitations to equal numbers, mostly two upstream and two downstream firms, that characterise other game–theoretic work.[1] A major result of Salinger's paper that has found wide consideration in the literature is that *vertically integrated firms do not participate in the market for the intermediate good, neither as a seller nor as a buyer.*[2] I show that Salinger's claim that the foreclosure result would hold for every conceivable market structure is incorrect. There are market structures that are conducive to vertical supply, and others that support vertical foreclosure.

I focus on the exclusion of downstream rivals from the integrated firm's input supplies to evaluate the logic of Salinger's foreclosure claim. I extend Salinger's formal model by making the supply decision endogenous in the first stage of a two-stage game and derive an explicit subgame–perfect solution for the intermediate good output of the integrated firm. The key result is that the existence of either the foreclosure or vertical supply equilibrium depends on the number of unintegrated up– and downstream firms and the number of vertically integrated producers. This qualifies Salinger's result as a special case, since vertical market foreclosure arises only for a restricted range of parameters.

The analysis is conducted within the following setting:

- successive oligopoly,
- differing numbers of upstream and downstream firms,
- homogeneous goods in both final and intermediate goods markets,
- fixed-coefficient technology, and
- constant-returns to scale in up- and downstream production.

[1] See Ordover, Saloner, and Salop (1990), Hart and Tirole (1990) and Bernheim and Whinston (1991). These papers restrict their attention to two upstream and two downstream firms.

[2] See Martin (1993) for a recent textbook that thoroughly discusses Salinger's model. Abiru, Nahata, and Waterson (1993) and Choi (1993) are very recent papers building upon the foreclosure claim.

The vertical market structure assumes partial integration, with both vertically integrated and unintegrated upstream and downstream firms being present in the markets.

The next section revises Salinger's argumentation and falsifies it with a simple example. Furthermore, it is shown that the argument Salinger uses to derive his foreclosure claim is fallacious. Section 3 extends Salinger's model and develops the integrated firms' supply decision. Using backward induction, the precise conditions for the emergence of the foreclosure (subsection 3.3) and supply equilibrium (subsection 3.4) are derived. Subsection 3.5 provides simulations of the integrated firm's intermediate good output. Section 4 interprets these results, while conclusions are given in section 5.

2 Vertically Integrated Firms and the Intermediate Good Market: A Reconsideration

Salinger makes the following assumptions about the conjectures a vertically integrated firm makes in assessing the effect of its actions on intermediate and final good producers[3].

1. (a) If a vertically integrated firm sells an extra unit of the intermediate good, it holds a *Cournot conjecture with respect to other intermediate good producers (integrated and unintegrated)* and (b) it conjectures that a(n) (unintegrated) final good producer increases its output by one unit.

2. (a) If a vertically integrated firm buys an extra unit of the intermediate good, it has a *Cournot conjecture towards other final good producers*, while (b) it conjectures that an (unintegrated) intermediate good producer expands its output by one unit.

3. The following inequalities hold: $c < p < z - m$. The first inequality implies that the upstream profit margin is positive, and the second inequality, $z - p - m > 0$ implies that unintegrated final good producers earn a positive profit.

[3] Unlike Salinger, I have divided the first two assumptions in two parts, (a) and (b), respectively.

The notation employed is

n_I	number of intermediate good producers
n_F	number of final good producers
n	number of vertically integrated producers
$n_I - n$	number of non-integrated intermediate good producers
$n_F - n$	number of non-integrated final good producers
$M = (n_F, n_I, n)$	vertical market structure
$z = a - bX$	inverse final demand function
p	intermediate good price
c	constant upstream average cost =constant internal transfer price
m	constant unit cost of transforming the intermediate into the final good
X	quantity of the final good
Q	quantity of the intermediate good

Note that assumptions 1(a) and 2(a) are Cournot assumptions with regard to horizontal competitors. Assumptions 1(b) and 2(b) warrant two further remarks. First, as is already expressed by Salinger, given the fixed-coefficients–technology and given that agents hold Cournot expectations, they become mere consistency requirements. Second, and more important, they are about extra units, i.e. *marginal* changes that leave the intermediate and final good prices unchanged.

Salinger claims that, given these three assumptions, a "vertically integrated firm chooses not to participate in the market for the intermediate good". Participation has two sides: buying and selling. I concentrate on the exclusion of unintegrated downstream rivals from the integrated firms' input supplies. This implies that "unintegrated final good producers lose a supplier" (Salinger, p. 345) as a consequence of vertical mergers. Integrated firms do not consider buying on the intermediate good market as a profitable strategy and are satisfying their input demand internally.

To show that for the integrated firms *selling* on the intermediate good market is unprofitable, Salinger suggests the following "scenario".

> ... (S)uppose that the firm sells (Q) units[4] of the intermediate good. Consider reducing sales of the intermediate good to 0 and increasing final good production by (Q). By the first assumption, the reduced sales of the intermediate good cause final good producers to reduce output by (Q). This exactly offsets the vertically integrated firm's increased output of the final good. The market output and, therefore, the price of the final good and revenues from inframarginal sales are not affected (p 348).

The change in profit is then equal to $(z - m)Q - pQ$, which by the third assumption is positive. Salinger concludes that

> (i)t may be surprising that the firm does not sell any of the intermediate good even if ($p > c$). The firm recognizes, however, that its sales of the intermediate good ultimately compete with its own final goods. Provided that (p) and (z) are such that it makes more money from final good sales than from intermediate good sales, it should use all of its intermediate good output internally (p. 348).

I show that the preceding scenario is fallacious. The following example provides some intuition of the fallacy behind it.

A Numerical Example and Suggested Interpretation

Salinger observes that "sales of the intermediate good by a vertically integrated firm affect its profit from final good sales. Thus, a vertical merger may give an intermediate good producer an incentive to restrict its sales of the intermediate good" (p. 347). This observation points to a *strategic effect* of an integrated firm's intermediate good supply decision since it foresees the impact of this supply decision on its second stage profit.[5] Thus, an integrated firm's intermediate good supply depends on its net marginal revenue from intermediate good sales *and* on the marginal change in its downstream profit function.

Since Salinger implicitly assumes that the foreclosure result applies generally within the aforementioned setting, a simple example suffices to provide a contradiction. Assume the following numerical specification: $a = 12$, $b = 1$, $c =$

[4] A somewhat different notation from Salinger's is used here. For this reason, the variables are bracketed in quotes from the original text.

[5] See Bulow, Geanakoplos, and Klemperer (1985) and Fudenberg and Tirole (1984) for an analysis of the sign of such strategic effects within a setting of sequential markets.

1, and $m = 1$ and let the vertical market structure be $(n_F, n_I, n) = (10, 5, 4)$. Salinger's equations (3a) and (3b) for final good Cournot output then become (in my notation), $x^v = \frac{1}{11}(4 + 6p)$ and $x^u = \frac{1}{11}(15 - 5p)$, where x^v represents the integrated firm's output and x^u the unintegrated firm's output. Aggregating unintegrated output yields $(n_F - n)x^u = \frac{6}{11}(15 - 5p)$. Applying the fixed–coefficients technology $(n_F - n)x^u = Q$ and solving for p gives the inverse derived demand function $p = 3 - \frac{11}{30}Q$ on which the upstream firms' marginal revenue is based. It is now *explicitly allowed* for integrated firms to sell a positive amount on the intermediate good market. Expressing the integrated firm's equilibrium profit from its downstream operations in terms of Q yields $\frac{1}{25}(Q - 10)^2$. The integrated upstream firm's profit function incorporates this strategic term as well as direct profit (total revenue minus total cost). To derive the Nash-Cournot equilibrium, note that there is only *one* unintegrated upstream firm $(n_I - n) = 5 - 4 = 1$, called firm "5", and that the four integrated firms are symmetric in their behaviour. The integrated firms profit as of stage 1 is $\Pi^v = (p - c)q^v + \frac{1}{25}(Q - 10)^2$. The intermediate good Cournot quantities are $q^5 = \frac{950}{517}$ for the unintegrated upstream producer (=firm number 5) and $q^v = \frac{230}{517} > 0$ for any of the four integrated firms. The integrated firms each supply a positive amount of the intermediate good to the market, and the total integrated output $nq^v = \frac{920}{517}$ comes near to total unintegrated output. I want to point out, however, that the result of positive intermediate good sales by integrated firms does not depend on the specific specification chosen but holds for a broad range of parameter values.

This simple example suggests that the claim that in general integrated firms fully foreclose their independent downstream rivals from their intermediate good supply must be wrong. The fallacy that lies behind this incorrect claim is that different equilibrium points of the same game are compared, one of which cannot be a subgame–perfect equilibrium. Assume, as does Salinger, that "unintegrated upstream producers move first and that the final good ... producers move second" (p. 349). Furthermore, assume that for a *given* market structure, a unique subgame–perfect equilibrium exists. Now suppose that the integrated firms' best responses to the other integrated and unintegrated firms' best responses is to restrict the intermediate good output to zero. By the definition of a Nash equilibrium, no player has an incentive to deviate unilaterally from its Nash strategy. Hence, foreclosure is the best an integrated firm can do under these circumstances and any comparison intended to find out whether the foreclosure outcome will be preferred or rejected to an imaginary outcome with a positive supply is pointless since it is predetermined. By the same token, vertical supply is preferred by the integrated firm if this is the Nash equilibrium strategy for each integrated firm in intermediate good market competition. Salinger's fallacy was to *assume ad hoc* that foreclosure is preferred to vertical supply in the first stage of the game, and then to *prove* it. In the remainder of the paper, the supply decision of a vertically integrated firm is derived within a more general framework by an extension of the model Salinger uses in his paper. The solution concept used is subgame–perfectness and it is found by backward induction.

3 Market Foreclosure: A Two-Stage Game Form

3.1 The Second–Stage (Downstream) Equilibrium: The Salinger Model

Our discussion of the equilibrium in the downstream industry reproduces Salinger's equations. The profit of the first integrated producer is[6]

$$\Pi^1 = (a - c - m - b\ X)x^1, \tag{1}$$

where $X = x^1 + ... + x^n + x^{n+1} + ... + x^{n_F}$ denotes total downstream output. The first-order condition for profit maximisation of (1) is

$$2x^1 + X^{-1} = (a - c - m)\,/b, \tag{2}$$

where X^{-1} is the final good output of the downstream industry except firm 1. The profit of the first unintegrated firm is given by

$$\Pi^{n+1} = (a - p - m - b\ X)x^{n+1}. \tag{3}$$

Comparing (1) and (3) reveals an important difference in the two firms' optimisation problems: The integrated firm's downstream unit pays c to obtain a unit of the intermediate input Q (which is transformed at cost m into output X). The unintegrated firm must pay the market price p to purchase a unit of Q, where this price is subject to oligopolistic manipulation by the integrated rivals. The first-order condition for profit maximisation of (3) is

$$2x^{n+1} + X^{-(n+1)} = (a - p - m)\,/b. \tag{4}$$

[6]The fact that the first integrated firm is considered has no special meaning. It is just a device to avoid the introduction of a further index.

Imposing symmetry such that $x^1 = ... = x^n = x^v$ and $x^{n+1} = ... = x^{N_F} = x^u$, the "condensed" first-order conditions are

$$(n+1)x^v + (n_F - n)x^u = (a - c - m)/b \tag{5}$$

and

$$(n_F - n - 1)x^u + nx^v = (a - p - m)/b. \tag{6}$$

Following Salinger, Cournot competition is assumed. The Cournot-Nash equilibrium of the downstream market is

$$x^v(N,p) = \frac{(a-c-m) + (n_F - n)(p-c)}{b(n_F+1)} \tag{7}$$

and

$$x^u(N,p) = \frac{(a-c-m) - (n+1)(p-c)}{b(n_F+1)}. \tag{8}$$

Equilibrium quantities (7) and (8) are written as functions of N and p to express their dependence on the intermediate good price and $N = (n, n_F)$, the vector of the number of integrated and unintegrated firms in the downstream industry.

Comparative Statics Consider an increase in p. The comparative statics effect is positive for the output of an integrated firm, $\frac{\partial x^v}{\partial p} = \frac{(n_F - n)}{b(n_F+1)} > 0$, and negative for an unintegrated firm, $\frac{\partial x^u}{\partial p} = -\frac{(n+1)}{b(n_F+1)} < 0$. This asymmetry provides an integrated firm with an incentive to foreclose its intermediate good supply: By reducing its intermediate good supply, possibly to zero, it increases the intermediate good price p and the costs of an unintegrated rival. Total downstream output is given by

$$\begin{aligned} X(N,p) &= (n_F - n)x^u(n,p) + n\, x^v(n,p) \\ &= \frac{1}{b(n_F+1)}[(a-m-p)n_F + (p-c)n]. \end{aligned} \tag{9}$$

One central argument in Salinger's original paper is that the final good market output (and the price) is not affected by an integrated firm's action in the intermediate good market. If an integrated firm reduces, say, its intermediate good sales, the balance of supply and demand and thus the intermediate good price is affected. Partially differentiating $X(n,p)$ with respect to p shows

$$\frac{\partial X(N,p)}{\partial p} = -\frac{(n_F - n)}{b(n_F+1)} < 0. \tag{10}$$

Since $n_F - n > 0$, the derivative is negative, and an increase in p reduces the input demand of the unintegrated final good producers more than it raises the output of the integrated firms. Equation (10) gives further evidence that the scenario discusses above was ill–constructed.[7]

Total unintegrated downstream output is given by $X^u(N,p) = (n_F - n)x^u$. Solving this expression for p using the fixed-coefficients technology $X^u(N,p) = Q(N,p)$, one obtains the inverse derived demand function for the intermediate good

$$p = c + \frac{b}{n+1}\left[(a-c-m)/b - \frac{n_F+1}{n_F-n}Q\right]. \tag{11}$$

3.2 The First (Upstream) Stage

Now suppose that, in perfect accordance with Salinger's argumentation, integrated firms foreclose independent upstream rivals from their purchases for integrated downstream requirements. I enlarge the strategy space of integrated firm in an natural way: They are allowed to enter into trading relationships with $n_F - n$ unintegrated downstream firms by selling strictly positive amounts of their intermediate good output. Thereby, the integrated firms play a Cournot game in the upstream industry with integrated and unintegrated competitors. Foreclosure, however, remains possible since an integrated firm can always choose to sell nothing of its output on the intermediate good market.[8]

[7]One might object that no price change will take place at all in the intermediate good market, since a final good producer logically must absorb the extra sales of the integrated firm. This argument, however, neglects the *sequential* nature of the moves of both firms. Only if they were acting simultaneously could any price change be potentially cancelled out. This cannot, however, be the case in a model with sequential moves, where the final good producers' input demand is forwarded to the market only *after* the intermediate good market has reached its equilibrium.

[8]Hart and Tirole (1990) argue that "(a) strategy that Salinger's upstream Cournot assumption does not permit is for an integrated supplier to undercut its nonintegrated rivals slightly, so that nonintegrated purchasers buy the same amount as before but now buy from the integrated supplier. Yet a price–cutting strategy seems natural, particularly in the context of many trading relationships between upstream and downstream firms that are personalized..." (Fn 50, p. 258). Within the framework of homogeneous goods, price–setting leads to the implausible competitive equilibrium outcome. It seems thus more "natural" to extend the model by allowing integrated firms to "oversupply" the market, compared with their supply of zero under the foreclosure assumption, rather than by introducing price–setting strategies upstream.

The Unintegrated Firm's Problem Consider the profit of the first unintegrated upstream firm,

$$\Pi^{n+1}(N,p) = \frac{b}{n+1}\left[\frac{a-c-m}{b} - \frac{n_F+1}{n_F-n}Q\right] q^{n+1}, \tag{12}$$

where $p(Q)$ is given by (11) and where $Q = n\ q^v + q^{n+1} + ... + q^{n_I}$ denotes total intermediate good output by the upstream industry. The first and second-order conditions for the maximisation of (12) are

$$\frac{b}{(n+1)}\left(\frac{a-c-m}{b} - \frac{(n_F+1)\left(2q^{n+1} + Q^{-(n+1)}\right)}{n_F-n}\right) = 0, \tag{13}$$

$$\frac{-2b(n_F+1)}{(n+1)(n_F-n)} < 0. \tag{14}$$

In the first-order-condition (13) the term $Q^{-(n+1)}$ represents the intermediate good quantities of the unintegrated upstream firms other than the first $n+1$'s firm, as well as the outputs of the n integrated firms.

The Integrated Firm's Problem Turning now to the first–stage optimisation problem of the first integrated firm, recall the existence of a strategic effect that affects first–stage optimisation. Thus, the profit function is

$$\begin{gathered}\Pi^1(N,p) = \max\left\{0,\ \tfrac{b}{n+1}\left[\tfrac{a-c-m}{b} - \tfrac{n_F+1}{n_F-n}Q\right] q^1\right\} + \\ \left[(a-c-m) - b\left((n_F-n)\,x^u(n,p) + n\ x^v(n,p)\right)\right] x^1(n,p),\end{gathered} \tag{15}$$

where the first term on the right–hand side of (15) gives the profit of (potentially) selling the intermediate good to the unintegrated downstream firms, and the second term represents the equilibrium profit of the first integrated firm's downstream operations. After substituting (11) in the expressions in (15), the profit expression becomes

$$\begin{gathered}\Pi^1(N,p) = \max\left\{0,\ \tfrac{b}{n+1}\left[\tfrac{a-c-m}{b} - \tfrac{n_F+1}{n_F-n}Q\right] q^1\right\} \\ + \tfrac{[b(Q-(a-c-m))]^2}{b(n+1)^2}.\end{gathered} \tag{16}$$

The first integrated firm maximises (16) subject to the non–negativity constraint $q^1 \geq 0$. Depending on the sign of q^1, a corner and an interior solution must be distinguished. The Kuhn–Tucker condition of the integrated firm's problem is

$$\begin{gathered}\frac{b}{(n+1)}\left[\frac{a-c-m}{b} - \frac{n_F+1}{n_F-n}\left(2q^1 + Q^{-1}\right)\right] \\ -\frac{2}{(n+1)^2}\left[a-c-m-b\left(q^1+Q^{-1}\right)\right] \leq 0,\end{gathered} \tag{17}$$

where Q^{-1} represents intermediate good output other than that of firm 1. The second order condition is $2b\,(n\,n_F + 2n + 1)\,/\,\left((n+1)^2\,(n - n_F)\right) < 0$ since $n_F - n > 0$. Since integrated and unintegrated upstream firms are alike, assuming symmetry: $q^1 = ... = q^n = q^v$ and $q^{n+1} = ... = q^{N_I} = q^\omega$; then $Q^{-i} = (n-1)q^v + (n_I - n)q^\omega$, where q^ω denotes the symmetric output of the unintegrated firms and q^v denotes the symmetric output of integrated firms. This leads to

$$\frac{b}{(n+1)}\left[\frac{a-c-m}{b} - \frac{n_F+1}{n_F-n}\left((n+1)\,q^v + (n_I - n)\,q^\omega\right)\right]$$
$$-\frac{2}{(n+1)^2}\left[a - c - m - b\,(nq^v + (n_I - n)\,q^\omega)\right] \leq 0. \tag{18}$$

The first term in (18) represents net marginal revenue from selling intermediate good output on the market. The second term with a negative sign represents the strategic effect that was mentioned earlier.[9] The following two possible equilibrium outcomes are distinguished:

$$q^v \equiv \left\{\begin{array}{c} q^v_S > \\ q^v_F = \end{array}\right\} 0 \quad \Rightarrow \left\{\begin{array}{c} \text{Supply Equilibrium} \\ \text{Foreclosure Equilibrium.} \end{array}\right.$$

The corner solution is equivalent to the foreclosure equilibrium. The interior solution will be referred to as a vertical supply equilibrium.

3.3 The Foreclosure Equilibrium

The conditions for a foreclosure equilibrium imply that $q^v \equiv q^v_F = 0$ in (18),

$$\frac{b}{(n+1)}\left[\frac{a-c-m}{b} - \frac{n_F+1}{n_F-n}\left((n_I - n)\,q^\omega_F\right)\right] \leq$$
$$\frac{2}{(n+1)^2}\left[a - c - m - b\left((n_I - n)\,q^\omega_F\right)\right]. \tag{19}$$

Rewriting (19) yields a condition for the unintegrated upstream firm's output q^ω_F that must be satisfied in a foreclosure equilibrium

$$q^\omega_F \geq \frac{a-c-m}{b}\,\frac{(n-1)(n_F-n)}{(n_I-n)\left[n_F(n-1)+3n+1\right]}. \tag{20}$$

[9]The negative sign corresponds to Bulow, Geanakoplos and Klemperer's (1985) analysis for linear demand and quantity competition.

At the foreclosure equilibrium, the reaction function of the unintegrated firm is given by (13) with $nq^v = 0$ and $Q^{-(n+1)} = (n_I - n - 1)\, q_F^\omega$. The symmetric Cournot–Nash output is

$$q_F^\omega(M) = \frac{(a-c-m)}{b} \frac{(n_F - n)}{(n_F+1)\,(n_I - n + 1)}, \tag{21}$$

where M denotes the vector $M = (n_F, n_I, n)$. Inserting the total unintegrated equilibrium output $(n_I - n)\, q_F^\omega$ into (11) yields the perfect equilibrium intermediate good price

$$p_F(M) = c + \frac{a-c-m}{(n+1)\,(n_I - n + 1)}, \tag{22}$$

that corresponds to Salinger's equation (5).

Substituting q_F^ω in (20) with the Cournot output $q_F^\omega(M)$ in (21),

$$\frac{(n_F - n)}{(n_F+1)\,(n_I - n + 1)} \geq \frac{(n-1)(n_F - n)}{(n_I - n)\,[n_F(n-1) + 3n + 1]} \tag{23}$$

gives after some manipulations the condition that must be satisfied for the foreclosure equilibrium to be admissible:

$$\frac{(n_F - n)\,(-\gamma)}{(n_F+1)\,(n_F\,(n-1) + 3n + 1)\,(n_I - n)\,(n_I - n + 1)} \geq 0, \tag{24}$$

where

$$\gamma \equiv (n\,(n_F - 2n_I + 2n + 3) - 2n_I - n_F - 1)\,.$$

Since the denominator of (24) and $n_F - n$ are positive, the foreclosure equilibrium is admissible for values of $\gamma \leq 0$. The term γ, however, depends only on M. Hence, the emergence of foreclosure is endogenous. For $\gamma > 0$, condition (24) is violated and the supply equilibrium becomes admissible.

3.4 The Supply Equilibrium

In addition to the condition $\gamma > 0$, further insights into the nature of the supply equilibrium can be gained by explicitly solving for the Cournot–Nash equilibrium in the upstream industry. Since now $q^v \equiv q_S^v > 0$, the first-order condition (17) must be equal to zero. The condensed reaction functions of the unintegrated and integrated firms can now be solved for the supply equilibrium quantities. For the vertically integrated firm,

$$q_S^v(M) = \max\left\{0, \frac{(a-c-m)}{b} \frac{(n_F - n)\,\gamma}{(n_F+1)\,\Lambda}\right\}, \tag{25}$$

where $\gamma \equiv n\,(n_F - 2n_I + 2n + 3) - 2n_I - n_F - 1$ was already defined above, and $\Lambda \equiv n\,(n_I\, n_F + n_I + 2n + 1) + n_F\,(n_I - n + 1) + n_I + 1$. For the unintegrated producer,

$$q_S^{\omega}(M) = \frac{(a-c-m)}{b} \frac{(n+1)\,(n_F - n)\,(n_F + 2n + 1)}{(n_F + 1)\,\Lambda}. \tag{26}$$

Since $\Lambda > 0$, (26) is strictly positive. According to (25), the integrated firm produces a strictly positive output if $\gamma > 0$, which corresponds to the condition derived in (24). The vertical supply equilibrium exists if $\gamma > 0$, and since then $-\gamma < 0$, both equilibrium constellations are mutually exclusive.

3.5 When is the Supply Equilibrium Admissible?

This section discusses the conditions that produce $\gamma > 0$ or $q_S^v(M) > 0$ in terms of relevant parameter values. Due to the partial integration assumption, the following restriction is placed upon M :

$$n \leq \min\{n_I - 1,\ n_F - 1\}.$$

Consider first the duopoly cases. If the upstream industry is a duopoly, $n_I = 2$ and $n = 1$. For this combination, $\gamma = -4$, independent of the magnitude of n_F. Now suppose that the downstream industry is duopolistic with $\mathrm{n}_F = 2$ and $n = 1$. Then, $\gamma = 4 - 4n_I \leq 0$ for $n_I \geq 1$. For the duopoly cases, foreclosure is the resultant equilibrium.

Moving beyond duopoly, the existence of a supply equilibrium depends upon the number of integrated and unintegrated firms in final and intermediate good markets (M). An analytical characterisation is not possible. Table 1 display $q_S^v(M)$ as computed in (25) as a function of n and n_F for a fixed value of $n_I = 5$.

Bold faced entries in Table 1 give values of $q_S^v > 0$.[10] These results show that the vertical supply equilibrium exists for a considerable range of parameter values. For small numbers of downstream firms, i.e. $n_F \leq 4$, the equilibrium outcome is foreclosure. This leads to the presumption that if there are only a few downstream competitors, the foreclosure equilibrium is supported. Once a level of $n_F = 5$ is reached, vertical supply becomes the equilibrium outcome if n is large, relative to its maximum of 4. In Table 1, $n = 4$ ensures vertical

[10]Alternatively, γ could have been tabulated. The conditions for the existence of either equilibrium remain exactly the same, of course.

n_F / n	**1**	**2**	**3**	**4**
3	0	0	–	–
4	0	0	0	–
5	0	0	0	**s/(129)**
6	0	0	0	**11s/(679)**
8	0	0	**5s/(837)**	**2s/(63)**
10	0	0	**7s/(407)**	**23s/(517)**
12	0	0	**15s/(559)**	**116s/(2119)**
14	0	0	**11s/(315)**	**7s/(111)**
16	0	0	**39s/(935)**	**82s/(1173)**
18	0	**8s/(2641)**	**55s/(1159)**	**329s/(4351)**
20	0	**s/(119)**	**221s/(4221)**	**424s/(5271)**
30	0	**182s/(6913)**	**207s/(3007)**	**1079s/(11191)**
40	0	**437s/(12013)**	**407s/(5207)**	**678s/(6437)**
50	0	**8s/(187)**	**2021s/(24021)**	**3289s/(29631)**

Table 1: **Values of q^v for $n_I = 5$**; $s = \frac{a-c-m}{b}$

supply for $n_F \geq 5$ and $n = 3$ is compatible with a supply equilibrium if n_F lies between 8 and16. For $n_F \in [18, 50]$, the "supply– inducing" n eventually reduces to 2. Even with a relatively low proportion of integrated firms in the downstream industry, vertical supply arises as the equilibrium if there are many nonintegrated downstream rivals.

For most combinations of numbers of upstream and downstream firms, a vertical supply equilibrium results once a critical number of integrated firms is reached. These critical numbers are tabulated in Table 2. To isolate the effects of variations of the three elements in M, consider the effect of a change in n_F first. According to Table 2, perhaps the most general statement one can make is that vertical supply arises if the number of downstream firms n_F is large, n is at least 2 and there are only a few upstream firms n_I. For intermediate values of n_F, 10 say, vertical supply arises only if, first, the number of upstream firms is not "too large" ($n_I \leq 10$), and, second, the proportion of integrated firms relative to total upstream firms, $\frac{n}{n_I}$, is greater than 1/2. Looking at n_I, foreclosure arises if there are many upstream firms and only a few downstream firms.

n_F/n_I	3	4	5	10	15	20	50
3	–	–	–	–	–	–	–
4	–	$n=3$	–	–	–	–	–
5	–	$n=3$	$n=4$	–	–	–	–
6	$n=2$	$n=3$	$n=4$	–	–	–	–
8	$n=2$	$n=3$	$n=3$	$n=7$	–	–	–
10	$n=2$	$n=3$	$n=3$	$n=7$	–	–	–
12	$n=2$	$n=2$	$n=3$	$n=6$	$n=10$	–	–
14	$n=2$	$n=2$	$n=3$	$n=6$	$n=10$	–	–
16	$n=2$	$n=2$	$n=3$	$n=5$	$n=9$	$n=13$	–
18	$n=2$	$n=2$	$n=2$	$n=5$	$n=8$	$n=12$	–
20	$n=2$	$n=2$	$n=2$	$n=4$	$n=8$	$n=12$	–
30	$n=2$	$n=2$	$n=2$	$n=3$	$n=5$	$n=8$	–
40	$n=2$	$n=2$	$n=2$	$n=3$	$n=4$	$n=6$	$n=32$
50	$n=2$	$n=2$	$n=2$	$n=2$	$n=3$	$n=5$	$n=28$

Table 2: **Critical values for n that ensure vertical supply**

4 Interpretation of the Results

In duopoly, either up–or downstream or in both industries simultaneously, vertical foreclosure is the equilibrium.[11] This setting is conducive to the "use" of foreclosure as a tool to effectively "raise rival's cost" (Salop and Scheffman 1983, 1987) through the increase in the intermediate good price p following the foreclosure decision that asymmetrically affects integrated and unintegrated downstream firms. With $M = (2, 2, 1)$, the integrated firm can now disadvantage its downstream rival by foreclosing its own intermediate good production and thus forcing it to rely on the remaining upstream monopolist (see also Perry 1989).

For the oligopoly case, the strategic incentive to raise rival's cost is modified by different combinations of M. The incentive to foreclose depends, other things kept constant, on the extent of the reallocation of final good output from nonintegrated to integrated producers induced by an increase in p. The strength of this effect is affected by the number of competitors in the downstream industry. If there are many competitors, the strategic effect of a foreclosure decision

[11]This suggests that the duopoly case is rather special in a linear framework. Nevertheless, it is in accordance with findings in the literature for general demand functions (Spencer and Jones 1991).

is weak: From the comparative statics results of section 3, $\frac{\partial x^u}{\partial p} = -\frac{(n+1)}{b(n_F+1)}$. Then, $\left|\frac{\partial x^u}{\partial p}\right|_{n_F\, large} < \left|\frac{\partial x^u}{\partial p}\right|_{n_F\, small}$. For the limiting case when the downstream industry approaches perfect competition, i.e. when the number of downstream firm goes to infinity,

$$\lim_{n_F\to\infty} q^v(M) = \frac{a-c-m}{b}\frac{n-1}{n(n_I-1)+n_I+1} > 0 \quad \text{for} \quad n>1. \qquad (27)$$

Perfect competition eliminates the strategic effect. As a consequence, vertical supply becomes the equilibrium strategy, save for the case of upstream duopoly ($n_I = 2$ and $n = 1$) discussed above.

The incentive to trade on the intermediate good market depends on the profitability of selling positive quantities of Q. This in turn depends on the number of upstream firms. If n_I is large, net marginal revenue from intermediate good sales is low and is less likely to outweigh the strategic effect. Taking the limit,

$$\lim_{n_I\to\infty} q^v(M) = \max\left\{0, -\frac{a-c-m}{b}\frac{2(n_F-n)(n+1)}{(n_F+1)^2(n+1)}\right\} = 0. \qquad (28)$$

If the intermediate good becomes perfectly competitive, vertical foreclosure arises as the equilibrium, irrespective of n_F and n.

For constant n_I and n_F, a variation of n has a dual effect. Integrated firms make their supply decisions simultaneously. If the ratio $\frac{n}{n_I}$ is large, a large share of intermediate good supply is potentially foreclosed with an accordingly strong upward impact on p. This effect works in favour of foreclosure. On the other hand, a large n implies a large ratio $\frac{n}{n_F}$ in the downstream industry. If $\frac{n}{n_F}$ is large, the gains from the output–restrictive effect of an increase in p are spread over a large number of integrated firms and are small for any single firm. From the results from section 3, $\left.\frac{\partial x^v}{\partial p}\right|_{n\, large} < \left.\frac{\partial x^v}{\partial p}\right|_{n\, small}$. This effect tends to favour vertical supply.

5 Conclusion

In this paper I reexamine the claim made by Salinger in his 1988 QJE paper that in a successive oligopoly framework with homogeneous goods and fixed coefficients, vertically integrated firms generally foreclose the intermediate good market. Focusing on the exclusion of unintegrated downstream competitors from the intermediate good production of integrated firms, the analysis shows that the foreclosure claim is incorrect as a general result and holds for special cases only. A simple example suffices to illustrate that it is profitable for integrated firms to trade on the intermediate good market if the market structure supports vertical supply. Viewed from the perspective of a two–stage game, the argument Salinger uses to derive the foreclosure results is identified as an implicit ad–hoc assumption: foreclosure is always preferred to vertical supply in the first–stage of the game. Section 3 of this paper derives the precise conditions for vertical foreclosure versus vertical supply to arise as a perfect Nash–Cournot equilibrium by explicitly allowing integrated firms to trade on the intermediate good market. The emergence of either of the two mutually exclusive equilibria is endogenous. It depends on the number of integrated firms and of unintegrated upstream and downstream firms. Foreclosure arises if the upstream as well as downstream industry is duopolistic. Moreover, a small number of downstream firms and a large number of upstream firms is favourable to foreclosure. Vertical supply, on the other hand, is admissible for a broad range of parameter values. A large number of downstream firms and a low number of upstream firms supports the vertical supply equilibrium.

In the light of these results, the widespread reception of Salinger's result in the vertical integration literature warrants a reexamination of those papers that model vertical mergers within an oligopoly framework.

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